CLAIMS

1. In a gait generating device equipped with instantaneous gait generating means for sequentially generating an instantaneous desired gait composed of an instantaneous desired motion of a mobile robot and an instantaneous desired floor reaction force,

a gait generating device of a mobile robot, comprising instantaneous desired motion correcting means,

wherein if:

all or a part of the mobile robot is expressed in terms of a model constructed of a plurality of elements, the elements being at least either rigid bodies having inertia or mass points;

a placement of elements of the model determined according to a predetermined first geometric restrictive condition, which specifies the relationship between an instantaneous motion of the mobile robot and the placement of the elements of the model, from an instantaneous desired motion generated by the instantaneous gait generating means is defined as a first placement;

a placement of the elements of the model determined according to a predetermined second geometric restrictive condition, which specifies the relationship between an instantaneous motion of the mobile robot and the placement of the elements of the model, from an instantaneous desired motion generated by the instantaneous gait generating means is defined as a second placement; and

a placement of the elements of the model determined according to the second geometric restrictive condition from a corrected instantaneous desired motion obtained by correcting at least either the position or the posture of a predetermined part of the mobile robot in an instantaneous desired motion generated by the instantaneous gait generating means is defined as a third placement; then

the instantaneous desired motion correcting means determines the corrected instantaneous desired motion such that a moment component generated about a predetermined point by a resultant force of inertial forces of the elements calculated by regarding the difference in the placement of the elements of the model between the third placement and the first placement as acceleration is closer to a predetermined value than a moment component acting about the predetermined point due to a resultant force of inertial forces of the elements calculated by regarding the difference in placement of the elements of the model between the second placement and the first placement as acceleration.

2. The gait generating device of a mobile robot according to Claim 1, wherein the instantaneous desired motion correcting means determines the corrected instantaneous desired motion such that a translational component of a resultant force F3 of the inertial forces of the elements calculated by regarding the difference in

placement of the elements of the model between the third placement and the first placement as acceleration is closer to zero than a translational component of a resultant force F2 of the inertial forces of the elements calculated by regarding the difference in placement of the elements of the model between the second placement and the first placement as acceleration, and a moment component acting about the predetermined point due to the resultant force F3 is closer to the predetermined value than a moment component acting about the predetermined point due to the resultant force F2.

3. In a gait generating device equipped with instantaneous gait generating means for sequentially generating an instantaneous desired motion of a mobile robot,

a gait generating device of a mobile robot comprising instantaneous desired motion correcting means,

wherein if all or a part of the mobile robot is expressed in terms of a model constructed of a plurality of elements, the elements being at least either rigid bodies having inertia or mass points,

a placement of the elements of the model determined according to a predetermined first geometric restrictive condition, which specifies the relationship between an instantaneous motion of the mobile robot and the placement of the elements of the model, from an instantaneous desired motion generated by the instantaneous gait

generating means is defined as a first placement, and

a placement of the elements of the model determined according to a predetermined second geometric restrictive condition, which specifies the relationship between an instantaneous motion of the mobile robot and the placement of the elements of the model, from a corrected instantaneous desired motion obtained by correcting at least either the position or the posture of a predetermined part of the mobile robot in the instantaneous desired motion generated by the instantaneous gait generating means is defined as a second placement, then

the instantaneous desired motion correcting means determines the corrected instantaneous desired motion such that a moment component acting about a predetermined point due to a resultant force of the inertial forces of the elements calculated by regarding the difference in placement of the elements of the model between the second placement and the first placement as acceleration becomes substantially a predetermined value.

4. The gait generating device of a mobile robot according to Claim 3, wherein the instantaneous desired motion correcting means determines the corrected instantaneous desired motion such that the translational force component of a resultant force of the inertial forces of the elements calculated by regarding the difference in placement of the elements of the model

between the second placement and the first placement as acceleration becomes substantially zero, and a moment component acting about the predetermined point due to the resultant force becomes substantially the predetermined value.

5. The gait generating device of a mobile robot according to Claim 1, wherein

in the moment component related to the difference in placement of the elements between the second placement and the first placement, the component originated from the difference between position A in the first placement and position B in the second placement of the elements of the model having masses is calculated from an angle formed by a segment connecting the predetermined point and the position A and a segment connecting the predetermined point and the position B by using a substantially monotonous function related to the angle, and

in the moment component related to the difference in placement of the elements between the third placement and the first placement, the component originated from the difference between position A in the first placement and position C in the third placement of the elements of the model having masses is calculated using the monotonous function from the angle formed by the segment connecting the predetermined point and the position A and the segment connecting the predetermined point and the position C.

6. The gait generating device of a mobile robot

according to Claim 3, wherein, in the moment component related to the difference in placement of the elements between the second placement and the first placement, the component originated from the difference between position A in the first placement and position B in the second placement of the elements of the model having masses is calculated from an angle formed by the segment connecting the predetermined point and the position A and the segment connecting the predetermined point and the position B by using a substantially monotonous function related to the angle.

7. The gait generating device of a mobile robot according to Claim 1 or 3, wherein the instantaneous desired motion generated by the instantaneous gait generating means is determined using a dynamic model that represents the relationship between a motion of the mobile robot and a floor reaction force and is constructed on the assumption that the inertial force generated by a specific motion component of at least one or more specific parts of the mobile robot is substantially zero, and the model includes an element corresponding to at least one part of the specific parts.

8. The gait generating device of a mobile robot according to Claim 1 or 3, wherein

an instantaneous desired motion generated by the instantaneous gait generating means is determined such that it satisfies a desired floor reaction force or a

desired ZMP on a predetermined dynamic model representing a relationship between a motion of the mobile robot and a floor reaction force, and

the first and the second geometric restrictive conditions are set such that a value obtained by adding a predetermined steady offset to the difference between a floor reaction force counterbalancing with a resultant force of the inertial forces of the elements that are generated due to temporal changes in the placement of the elements of the model determined according to the first geometric restrictive condition from the instantaneous desired motion and a floor reaction force counterbalancing with a resultant force of the inertial forces of the elements that are generated due to temporal changes in the placement of the elements of the model determined according to the second geometric restrictive condition from the instantaneous desired motion substantially coincides with an error of a floor reaction force produced on the dynamic model by the instantaneous desired motion.

9. The gait generating device of a mobile robot according to Claim 1 or 3, wherein

an instantaneous desired motion generated by the instantaneous gait generating means is determined so as to satisfy a desired floor reaction force or a desired ZMP on a predetermined dynamic model representing a relationship between a motion of the mobile robot and a floor reaction force, and

the first and the second geometric restrictive conditions are set such that a value obtained by multiplying the difference between the overall center-of-gravity of the placement of the elements of the model determined according to the first geometric restrictive condition from the instantaneous desired motion and the overall center-of-gravity of the placement of the elements of the model determined according to the second geometric restrictive condition from the instantaneous desired motion by the total mass of the elements substantially coincides with a value obtained by multiplying an error of the overall center-of-gravity of the dynamic model in the instantaneous desired motion by a total mass of the dynamic model.

10. The gait generating device of a mobile robot according to Claim 1 or 3, wherein the mobile robot is a robot comprising a plurality of legs or a plurality of arms extended from its body as a plurality of movable members, and the first geometric restrictive condition includes a condition in which any one of the elements of the model exists on a straight line parallel to a segment connecting a predetermined point in the vicinity of a distal end of each movable member and a predetermined point in the vicinity of the connecting portion of the movable member that is connected to the body.

11. The gait generating device of a mobile robot according to Claim 1 or 3, wherein the mobile robot is a

robot comprising a plurality of legs or a plurality of arms extended from its body as a plurality of movable members, and the first geometric restrictive condition includes a condition in which the body and the movable members on the model are retained in a predetermined constant posture state.

12. The gait generating device of a mobile robot according to Claim 11, wherein the predetermined constant posture is the posture in which the body and the plurality of movable members of the mobile robot are oriented substantially in the vertical direction.

13. The gait generating device of a mobile robot according to Claim 1 or 3, wherein the second geometric restrictive condition is set such that the placement of the elements of the model determined according to the condition from an arbitrary instantaneous desired motion of the mobile robot substantially coincides with the placement of parts corresponding to the elements in the robot following the instantaneous desired motion.

14. The gait generating device of a mobile robot according to Claim 1 or 3, wherein the mobile robot comprises a plurality of legs or a plurality of arms extended from the body as a plurality of movable members and also has flexible joints at middle portions between the connecting portions of the movable members that connect to the body and the distal ends of the movable members, and an instantaneous desired motion generated by

the instantaneous gait generating means is determined using a dynamic model that represents a relationship between a motion of the robot and a floor reaction force and the dynamic model is constructed on the assumption that the inertial forces produced at or near the middle portions of the movable members due to bending motions of the movable members are substantially zero, the model being a model that contains, as an element, a mass point associated with at least the middle portion or a portion near the middle portion of each movable member.

15. The gait generating device of a mobile robot according to Claim 14, wherein the first geometric restrictive condition includes a condition in which a mass point associated with the middle portion or the portion close thereto of each movable member of the elements of the model exists on the segment that connects a predetermined point in the vicinity of the distal end of the movable member and a predetermined point in the vicinity of the connecting portion of the movable member that links with the body, and the second geometric restrictive condition is set such that the placement of the elements of the model determined according to the condition from an arbitrary instantaneous desired motion of the mobile robot substantially coincides with the placement of parts corresponding to the elements in the robot following the instantaneous desired motion.

16. In a gait generating device of a mobile robot,

comprising an instantaneous gait generating means for sequentially generating an instantaneous desired motion of a mobile robot that is equipped with a plurality of legs extended from its body and has a flexible joint at a middle portion between a connecting portion of each leg that connects to the body and the distal portion of the leg, the instantaneous desired motion being generated by using a dynamic model that represents the relationship between a motion of the robot and a floor reaction force and is configured on the assumption that the inertial force produced at or near the middle portion of the leg due to a bending motion of each leg is substantially zero,

a gait generating device of a mobile robot, further comprising instantaneous desired motion correcting means that corrects an instantaneous desired motion such that, when generating a gait in which the joint of the middle portion of each leg is bent to reduce the length of a segment connecting a predetermined point in the vicinity of the distal portion of each leg and a predetermined point in the vicinity of the connecting portion of the leg that links to the body so as to protrude the joint in the direction intersecting with the segment at least from a state wherein the robot is in an upright posture state or a state of posture close thereto, the position of the connecting portion between the body and each leg is changed from the position of the connecting portion determined by an instantaneous desired motion generated by

the instantaneous gait generating means to substantially the opposite direction from the direction into which the joint of the middle portion of the leg protrudes, and also the position of an upper end relative to a lower end of the body is changed from the position of the upper end relative to the lower end of the body determined by an instantaneous desired motion generated by the instantaneous gait generating means to substantially the same direction as the direction into which the joint of the middle portion of the leg protrudes.

17. In a gait generating device of a mobile robot, comprising an instantaneous gait generating means for sequentially generating an instantaneous desired motion of a mobile robot that is equipped with a plurality of legs or a plurality of arms extended from the body as a plurality of movable members and also has flexible joints at middle portions between the connecting portions of the movable members that connect to the body and the distal portions of the movable members, the instantaneous desired motion being generated using a dynamic model that represents a relationship between a motion of the robot and a floor reaction force and the dynamic model is constructed on the assumption that the inertial forces produced at or near the middle portions of the movable members due to bending motions of the movable members are substantially zero,

a gait generating device of a mobile robot, further

comprising an instantaneous desired motion correcting means for correcting a desired instantaneous motion by determining the correction amount of at least either the body position or the body posture of an instantaneous desired motion generated by the instantaneous gait generating means according to a feedforward control law on the basis of the bending angle of the joint of the middle portion of the movable member, and then correcting at least either the body position or the body posture of the instantaneous desired motion on the basis of the determined correction amount.

18. The gait generating device of a mobile robot according to Claim 17, wherein the movable members are legs, and the instantaneous desired motion correcting means determines the correction amount such that the body posture of the instantaneous desired motion is further inclined forward and the position of the overall center-of-gravity of the mobile robot, excluding the plurality of movable members, is further displaced backward, as the bending angles of the joints of the middle portions of the movable members increase.

19. In a gait generating device of a mobile robot, comprising an instantaneous gait generating means for sequentially generating an instantaneous desired motion of a mobile robot that is equipped with a plurality of legs or a plurality of arms extended from its body as a plurality of movable members and also has flexible joints

at middle portions between the connecting portions of the movable members that connect to the body and the distal portions of the movable members, the instantaneous desired motion being generated using a dynamic model that represents a relationship between a motion of the robot and a floor reaction force and the dynamic model is constructed on the assumption that the inertial forces produced at or near the middle portions of the movable members due to bending motions of the movable members are substantially zero,

a gait generating device of a mobile robot, further comprising instantaneous desired motion correcting means for correcting a desired instantaneous motion by determining the correction amount of at least either the body position or the body posture of an instantaneous desired motion generated by the instantaneous gait generating means according to a feedforward control law on the basis of the relative positions of a segment connecting the predetermined point in the vicinity of the distal portion of each movable member and a predetermined point in the vicinity of a connecting portion of the movable member that connects to the body and the center-of-gravity of a link connected to the center of a joint at the middle portion of the movable member or to the joint in the direction for intersecting with the segment, and then by correcting at least either the body position or the body posture of the instantaneous desired motion on

the basis of the determined correction amount.

20. The gait generating device of a mobile robot according to Claim 19, wherein the movable members are legs, and the instantaneous desired motion correcting means uses the distance between the segment and the center of the joint of the middle portion of the movable member or the center-of-gravity of the link connected to the joint as the relative position, and determines the correction amount such that the body posture of the instantaneous desired motion is further inclined forward and the position of the overall center-of-gravity of the mobile robot, excluding the plurality of movable members, is displaced further backward, as the distance increases.